MERGING TELEMEDICINE WITH KNOWLEDGE MANAGEMENT: THE M2DM PROJECT

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Abstract -**This paper describes the EU-funded M2DM project which is developing multi-access services for the management of diabetes mellitus. Key features of the proposed system include the merging of telemedicine with knowledge management. The issues needing to be addressed in this connection are considered, together with the setting of the project within an overall systemic, model-based framework.**
Keywords - **Diabetes mellitus, telemedicine, web-based services, knowledge management, model-based framework**

I. INTRODUCTION

Diabetes mellitus is one of the major chronic diseases in western countries. Including its secondary complications, it can account for up to 8-10% of total national healthcare expenditure. As with many chronic diseases, the diabetic patient should play an active role in their own disease management and progressively learn how to customise therapeutic actions in response to problems associated with their glucose metabolism. Two long-term intervention trials on diabetic patients [1,2], have clearly demonstrated that the definition and realisation of the appropriate individual therapeutic goal is the key to effective diabetes care.

The means of achieving such goals, in terms of therapy and other lifestyle interventions, are available throughout most of the developed countries. However, effective healthcare delivery is still hampered by structural and organisational deficits. These include inequity in distribution of medical expertise, say between the city with its specialist diabetic centre and the rural area, and variability in access to information regarding their disease and its management for the diabetic patient. The adoption of information and communications technologies (ICT) enables some of these issues to be addressed, particularly those linked with information provision. This is increasingly central to the infrastructure associated with healthcare organisation and delivery as almost all countries worldwide engage in the process of re-engineering their national healthcare services and provision. Such ICT adoption, coupled with the professionals able to use such technology to best effect, can enable healthcare organisations to become more knowledge based and cost-effective in their operation. In relation to diabetes management there is already more than 25 years of ICT application. Details of some of this history and the evolution of information management and decision support systems can be found in [3] and [4].

II. THE M2DM PROJECT

M2DM builds on much of this earlier work. Some of its ingredients can be traced back to the first European-funded project 'Eurodiabeta' [5,6]. It is also extends research work undertaken as part of the EU 4th Framework T-IDDM project [7]. In essence this EU-funded project focuses on providing multi-access services for the management of diabetes. It offers a distributed environment for the application and management of operational knowledge in diabetes care. The goal is to establish a sustainable service of care to both residential and mobile diabetics; increasing the quality of care afforded to the patient through improved communication between patients and caregivers. This new open system is designed to provide more than traditional *telemedicine*, in which a central provider gives *care at a distance.* Here the healthcare organisation and the patient cooperate in order to maintain knowledge for improving the quality of care *regardless of distance.*

M2DM is being devised to incorporate new telemedicine services, emphasising the provision of personal health services 24 hours per day and offering new means by which the physician, other healthcare professionals and the patient can have access to information. Within the project, a Multi-Access Server (MAS) is defined, based on web and Computer Telephony Integration (CTI) servers. These will embed a range of technical implementations allowing access to a wider range of services; including: consultation of patients' records, text and voice mailing, printing of reports, alarm management, visit management telecare, tele-education and intelligent therapy advising. M2DM will also offer the capability of effectively managing the knowledge necessary for the complex process of chronic disease care, providing proper technological instruments and infrastructure. Distinctive features will be its capability to learn (a) how patients respond to therapy, their attitudes towards the system and their preferences; (b) how physicians are trying to solve management problems; and

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(c) about the complex process of chronic care management, tracking and modelling the information exchange between the agents involved in the process.

III. A MODEL-BASED FRAMEWORK

A key feature is the need to combine effectively the telemedicine and knowledge management functionalities. However, given the complexity of the proposed system, there is the need to have the whole project soundly based in a systemic, model-based framework [10].

The intended M2DM environment exhibits all the multi-attribute, multivariable and multi-perspective features of complexity. Whilst the clinical and technical advances in healthcare delivery are the main focus of attention, the most difficult issues to deal with are usually the social, economic, organisational and political ones. A systems approach enables all causal relations and influences to be captured in relation to the system of interest [9]. Model-based systems thinking is an important driver within the M2DM project.

Accordingly, in parallel with initial technical development in relation to the multi-access server, models of diabetes management organisations were undertaken in the early stages of the project. Models of the current national organisation of diabetes care were developed in terms of workflow, dataflow and patient flow. From these country-specific models a generic model was produced. This, in turn, was used to identify the organisational impact of introducing a telematic component of patient management in terms of the additional agents implied by the telemedicine services. These models have thus been used to inform the requirements specification of the telemedicine information system.

This modelling activity has been used in the telematic system specification and will also form the basis of much of the project evaluation activity, particularly in both organisational and economic evaluation. For instance, the models of diabetes care organisation will be used together with data relating to the uptake of telematic services. In particular, the workflow models will be used to identify changes in workflow at the organisational level as a result of introducing the M2DM multi-access services. These models will then provide a basis for assessing the extent to which the additional organisational components relating to telematic encounters/transactions are being made use of, as evidenced by the data collected during evaluation of the M2DM system

IV. THE ROLE OF TELEMEDICINE

Telemedicine has been defined [6] as "the investigation, monitoring and management of patients and the education of patients and staff using systems which allow ready access to expert advice and patient information no matter where the patient or relevant information is located." Its essence is information exchange at a distance [10]. Nymo [11] describes Einthoven's work in 1906 using telephones to transmit early electrocardiogram recordings as the first such information exchange. Another recent review identifies four main phases of telemedicine development, starting with telegraphy and telephony with its roots in the 19th century, via radio and television/space technologies to the digital systems of the 1990s onwards [12].

A. M2DM: Merging Telemedicine with Knowledge Management

Telemedicine can augment conventional methods of healthcare delivery, providing high-quality healthcare for everyone, everywhere [13]. M2DM has the motto *"giving the right knowledge to the right people in the right form at the right time at the right cost."* Home monitoring of diabetic patients has the potential of improving the quality and outcomes of healthcare by allowing more frequent and regular monitoring. Home monitoring could also be more efficient than traditional practice which typically involves the patient having to attend regularly at an outpatient clinic. This latter form of monitoring is time-consuming and can result in substantial disruption to a patient's busy work or home schedule, leading to low compliance [14]. Glucose meters linked to the telephone transmit the results of blood glucose and fructosamine tests performed by the patient, as well as any other relevant information to the M2DM server for analysis and advice. M2DM will also provide *tele-education* to patients, which can dramatically improve the outcomes of diabetes care and reduce its long-term complications.

B. Benefits and Drawbacks of Telemedicine Services such as M2DM

The benefits of telemedicine include: (i) improved access to information for healthcare professionals and for patients and the public in general; (ii) provision of care in medically underserved areas such as remote rural locations, thus improving the equity of access to care both between and within regions; and (iii) faster access for patients to healthcare professionals, with increased convenience and savings in travel time [13].

However, claims of reduced healthcare costs from telemedicine still need to be demonstrated by the carrying out of large scale trials. M2DM's multi-centre evaluation is scheduled for completion during 2002. Moreover, evidence gained from properly conducted clinical trials is likely to be the only way to change the sceptical opinion of those healthcare professionals strongly opposed to telemedicine

(notwithstanding the value of the model-based framework referred to above which can be seen as complementing the clinical trial approach!).

The provision of more services in primary care (instead of in hospitals) and ultimately in patients' homes is a major goal for healthcare delivery in many countries, not least in those represented in the M2DM consortium. In the longer term telemedicine will dramatically reduce the overall costs of health services by allowing a fundamental restructuring of healthcare delivery; specifically redistributing resources from the hospital environment to primary care [13]. This could be especially true with the use of *intelligent* telemedicine systems like M2DM that attempt to provide smart data analysis and knowledge management functions which are currently only to be found in the acute hospital setting, in addition to conventional telemedicine facilities.

In the opinion of the authors, telemedicine systems such as M2DM can also contribute to a reduction in waiting lists in countries, such as the UK, where this is a major problem. This can be achieved by facilitating a quick tele-screening of cases before referring them to a consultant, e.g. to an ophthalmologist for diabetic retinopathy, thus saving unnecessary referrals. Also, early and more convenient tele-consultation and effective treatment have the potential of reducing the long-term complications of diabetes mellitus and therefore the need for referrals to treat these complications.

Against the benefits of systems such as M2DM need to be set the potential drawbacks; issues which are being seriously addressed in the project workplan. These include: (i) a poorer relationship between healthcare professional and patient; (ii) a breakdown in relationships amongst healthcare professionals; (iii) healthcare workers perceiving telemedicine as a threat to their traditional role and status, or as carrying with it the potential of increasing their current workload; (iv) examinations where palpation is an important component cannot be carried out using current telemedicine technology (in such cases the tele-specialist can only rely on the findings of another healthcare worker who carried out a face-to-face examination of the patient); (v) quality of information issues (including the automated processing/analysis/interpretation performed by the system); and (vi) the need for major organisational changes in the way in which healthcare is provided and for the many bureaucratic difficulties to be overcome.

C. Establishing the Safety of M2DM

The duration of the evaluation phase of M2DM will be one year (January to December 2002) with four participating clinical centres from Germany, Italy and Spain. Before the start of this evaluation, training needs to be provided so as to familiarise all users with the different aspects of M2DM and to teach them the skills required to operate their equipment. This includes the sending of data stored in a glucometer to the M2DM server, whilst bypassing any irrelevant technical details [13]. Regarding safety, there will be the need to ensure: (i) that using telemedicine, the information of interest can be presented in a way that does not hinder its interpretation, compared with traditional methods of communication, storage and display; and (ii) that the overall process of management by telemedicine does not disadvantage the patient compared with care delivered by conventional means (the gold standard) [14]. In M2DM, the integrated automatic analysis and interpretation of uploaded patient data put additional demands on any evaluation/validation study, as there is the need to ensure that the system is always providing reliable and safe interpretation and advice.

V. ISSUES OF KNOWLEDGE MANAGEMENT AND FUTURE CHALLENGES

The services to be provided by M2DM range from diagnostic data analysis to therapy planning and educational services. These are in addition to address books (physician locator), diabetes related product catalogues and text and voice communication services. In terms of implementing clinical knowledge management technologies, a number of issues needing to be considered have recently been highlighted [15].

For better health outcomes, decision support, workflow and other knowledge based systems such as the proposed M2DM service should be integrated with electronic patient records. Ideally, a standardised clinical terminology should also be used (though this is not currently part of the M2DM implementation plan) to ensure consistent meaning across the different modules/language versions of the service and for successful system management and maintenance. The physician locator and other address databases within M2DM are better managed in a robust and more flexible Geographical Information System (GIS) environment such as the American HealthQuery system [16].

Methods and tools are also needed for creating, publishing and maintaining the evidence-based educational content of M2DM's professional and patient knowledge bases. The selection and compilation of material for inclusion in M2DM's educational knowledge bases can be very tricky, as many available resources have hard-to-spot biases or inaccuracies, and must therefore be excluded. This is the well known *quality* issue. However, problems with the quantity of information made available can also arise and impact negatively upon users of M2DM's educational knowledge bases. Information overload is already a reality for many healthcare workers, making it almost impossible

to keep up to date with developments in their own field [13]. Knowledge management plays an important role in the organisation, maintenance, retrieval, navigation and presentation of knowledge assets in efficient and effective ways. Emerging standards such as ISO Topic Maps could also help in this respect [17].

Adopting systems like M2DM implies new working styles by healthcare professionals; but it can be difficult to convince and train caregivers to embrace new ways of working. It also needs organisational changes to foster effective dissemination and productive use of the best current medical knowledge and evidence. Effective communication amongst healthcare professionals and with the patient, is secured via M2DM's multiple access modalities, based on the latest web and computer telephony integration. However, means for regulating the safe and ethical use of the service must be effected where needed, e.g. to ensure patient data security and confidentiality.

Partnership between patient and caregiver in the healthcare process must be reflected in the design, implementation and evaluation. The ultimate goal of M2DM must be to keep the *patient at the centre of care,* using adequate technology to empower patients and their caregivers, without raising digital barriers to the normal human relationships that need to exist between them.

VI. Summary

M2DM offers the prospect of enhancing the availability of diabetic care through the provision of its multi-access services, including utilisation both of the web and computer telephony integration. This paper has highlighted a number of the major issues being addressed and identified future challenges. First, given the complexity of the domain being addressed, the importance of adopting a systemic model-based framework is paramount; playing a role not only in relation to requirements specification for telematic service provision, but also organisational and economic evaluation. Secondly, the project involves the bringing together of the key dimensions of telemedicine and knowledge management and the paper has identified issues being tackled in order to bring this about in a successful manner.

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